197.

76862

NASA CASE NO. LAR-13,689-1 NP

PRINT FIG. 5

NOTICE

The invention disclosed in this document resulted from research in aeronautical and space activities performed under programs of the National Aeronautics and Space Administration. The invention is owned by NASA and is, therefore, available for licensing in accordance with the NASA Patent Licensing Regulation (14 Code of Federal Regulations 1245.2).

To encourage commercial utilization of NASA-owned inventions, it is NASA policy to grant licenses to commercial concerns. Although NASA encourages nonexclusive licensing to promote competition and achieve the widest possible utilization, NASA will consider the granting of a limited exclusive license, pursuant to the NASA Patent Licensing Regulations, when such a license will provide the necessary incentive to the licensee to achieve early practical application of the invention.

Address inquiries and all applications for license for this invention to NASA Patent Counsel, Langley Research Center, Mail Code 279, Langley Station, Hampton, VA 23665. Approved NASA forms for application for nonexclusive or exclusive license are available from the above address.

LaRC

(NASA-Case-LAR-13689-1-NP) RFID QUANTIFICATION OF AN INTERNAL PROPERTY Patent Applicatior (NASA) 19 p Avail: NTIS HC A02/MF A01 CSCL 14B

N87-23941

Unclas G3/35 0076862

RAPID QUANTIFICATION OF AN INTERNAL PROPERTY

AWARDS ABSTRACT

NASA Case No. LAR 13689-1

A device and method for the rapid quantification of an internal property of a material are typified by embodiments for rapidly quantifying the amount of urine in the bladder of a human subject.

Ultrasonic transducer 1, which is positioned on human subject 2 in proximity to bladder 12-13, is excited by pulser/receiver 3 under command of logic 4 to launch an accoustic wave into subject 2. This wave interacts with bladder walls 12, 13, and amplified and processed by pulser/receiver 3. The resulting signal is digitized by analog-to-digital converter 5 under command of logic 4, and is stored in memory 6. The software in logic system 4 determines the amount of urine in the bladder as a function of the propagated ultrasonic energy, based on programmed scientific measurements and past history of the particular human subject, and sends out a signal to turn on any of the audible alarm 7, the visible alarm 8 the tactile wireless alarm 10.

The novelty of this invention resides in the provision of a method and a device for the rapid quantification of an internal property of a material as a function of energy (especially ultrasonic energy) transmitted into the material and reflected therefrom. That is to say, changes in the propagated signal are related to a function of the desired monitoring variable. In the preferred embodiment energy signals over a number of measurement cycles are averaged to rapidly quantify the amount of urine in the bladder of a human subject. Moreover, the programming of specific functions of the particular subject into the logic system permits a fine tuning which affords accurate operation with a wide variety of subjects and conditions.

Inventors: John Companion
Home Address: 20 A Curtis Lane
Hampton, VA 23669
SS#: [redacted]

Joseph S. Heyman
130 Indian Springs Road
Williamsburg, VA 23185
SS#: [redacted]

Al Cavalier
1838 Carriage House Cr.
#2003
Experimental Psychology
Arlington, TX 76011
SS#: [redacted]

Beth Mineo
1800 Old Pond Dr.
#2607
Communication Disorders
Arlington, TX 76011
SS#: [redacted]

Travis Blalock
1009 Laurel Hill Rd.
Knoxville, TN 37923
SS#: [redacted]

Employer: NASA - Langley Research Center
Association for Retarded Citizens
Kentron

Initial Evaluator: Paul M. Yeager

Serial No.: 929,869

Filed: November 13, 1986

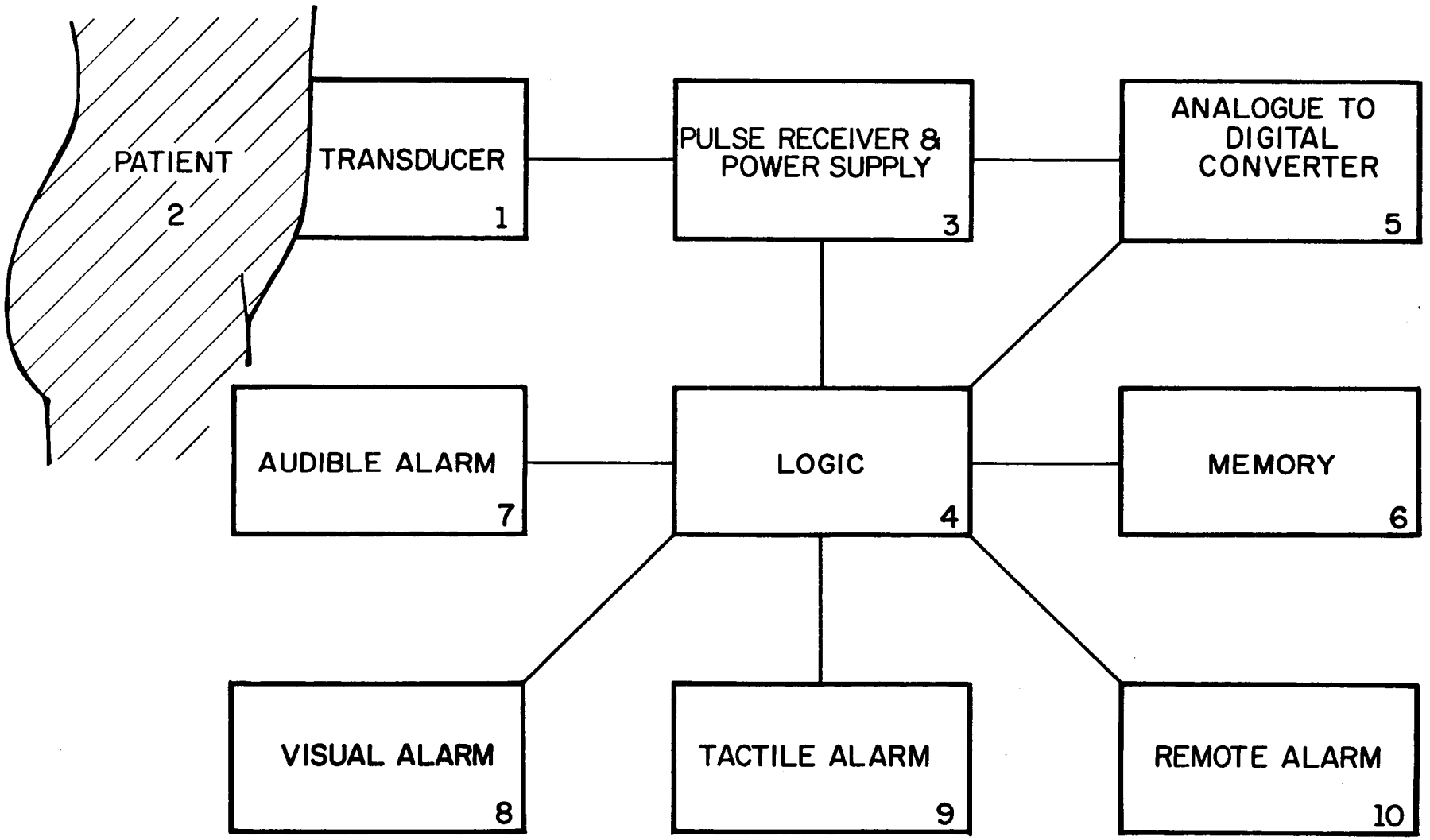
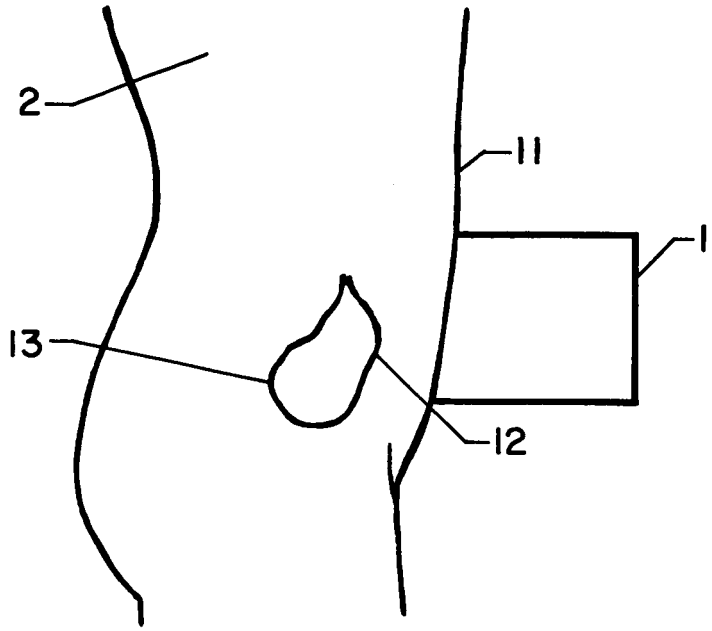
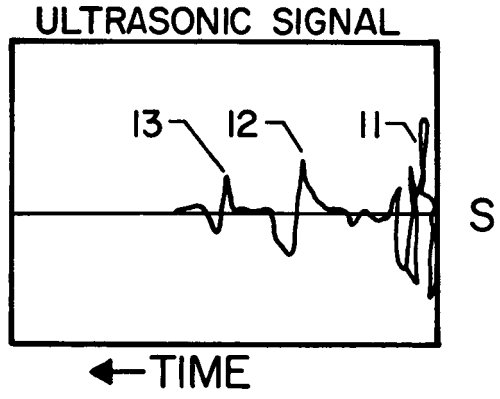

PATIENT
2
TRANSDUCER
1
PULSE RECEIVER &
POWER SUPPLY
3
ANALOGUE TO
DIGITAL
CONVERTER
5
AUDIBLE ALARM
7
LOGIC
4
MEMORY
6
VISUAL ALARM
8
TACTILE ALARM
9
REMOTE ALARM
10

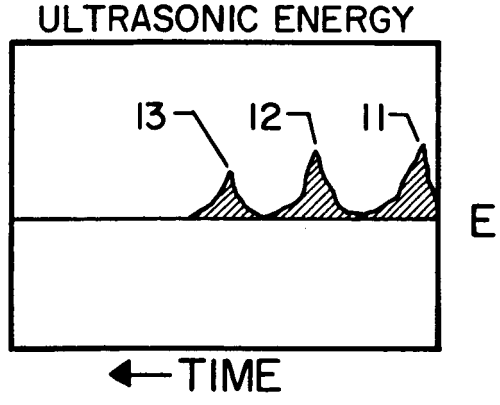
FIGURE 1

NASA CASE NO. LAR 13689-1-NP
Sheet No. 1 of 6
Inventor: James C. Fletcher, et al

FIGURE 2

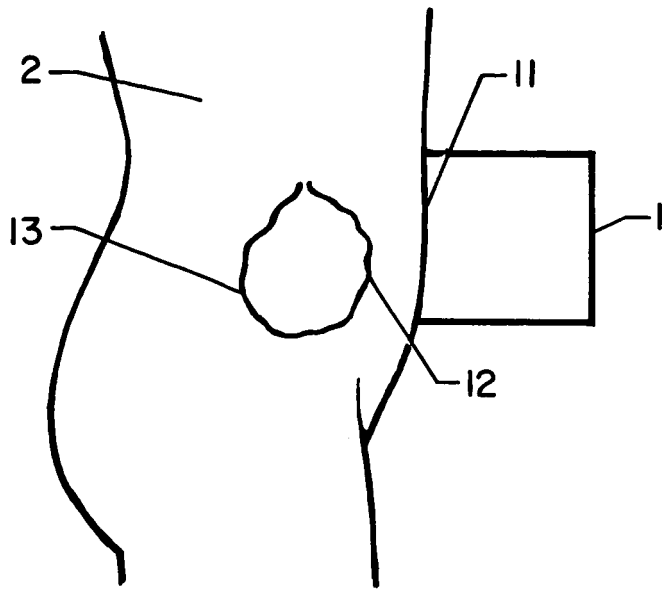

2
11
1
13
12

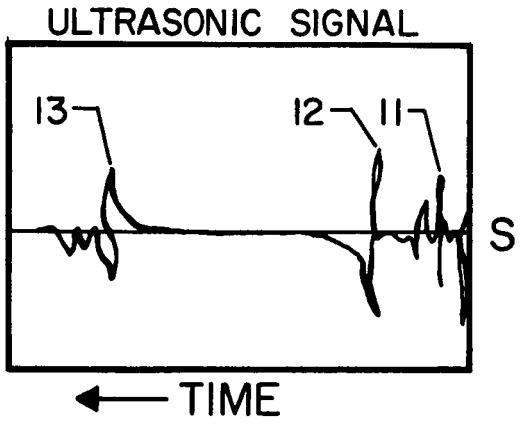

ULTRASONIC SIGNAL
13
12
11
S
TIME

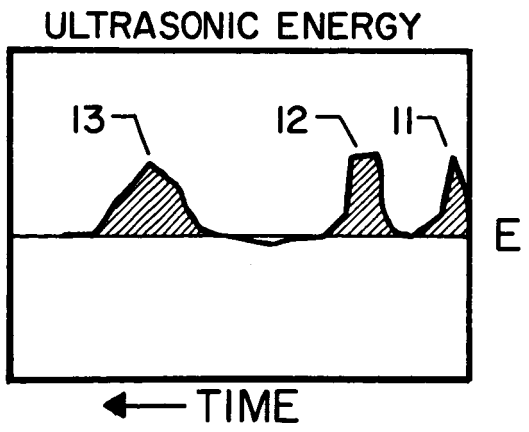

ULTRASONIC ENERGY
13
12
11
E
TIME

NASA CASE NO. LAR 13689-1-NP
Sheet No. 2 of 6
Inventor: James C. Fletcher et al

FIGURE 3

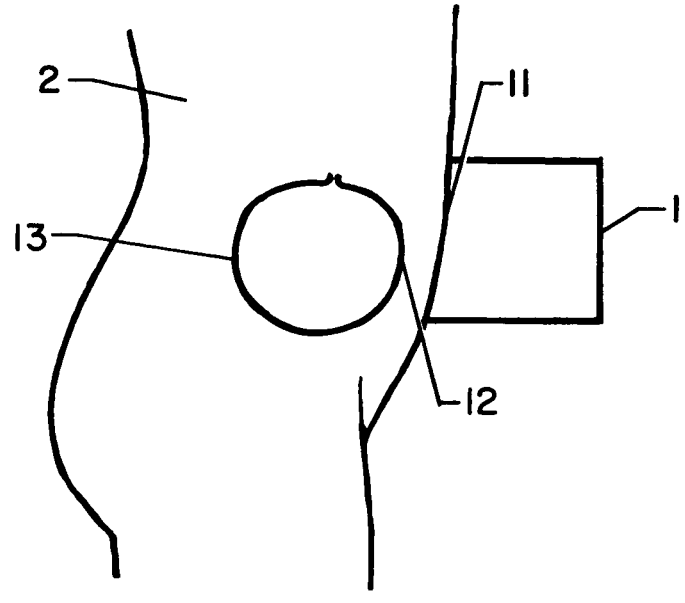

2
11
1
13
12

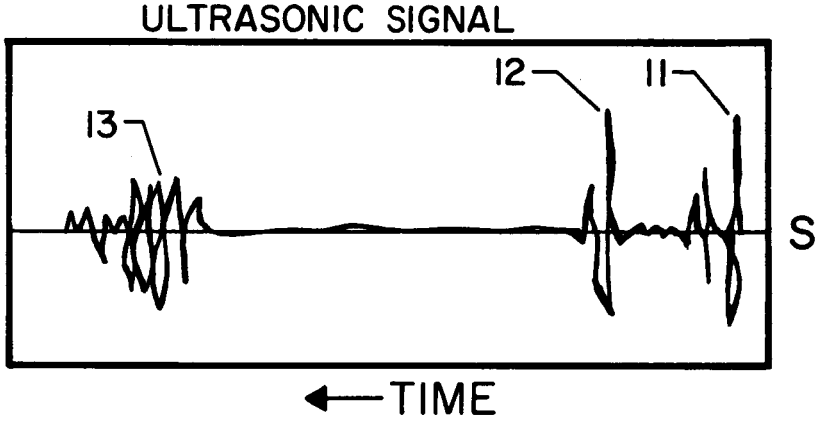

ULTRASONIC SIGNAL
13
12
11
S
TIME

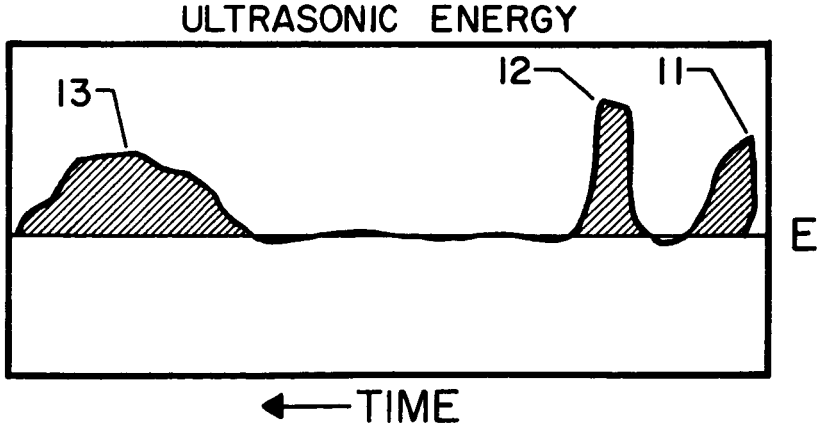

ULTRASONIC ENERGY
13
12
11
E
TIME

NASA CASE NO. LAR 13689-1-NP
Sheet No. 3 of 6
Inventor: James C. Fletcher et al

FIGURE 4

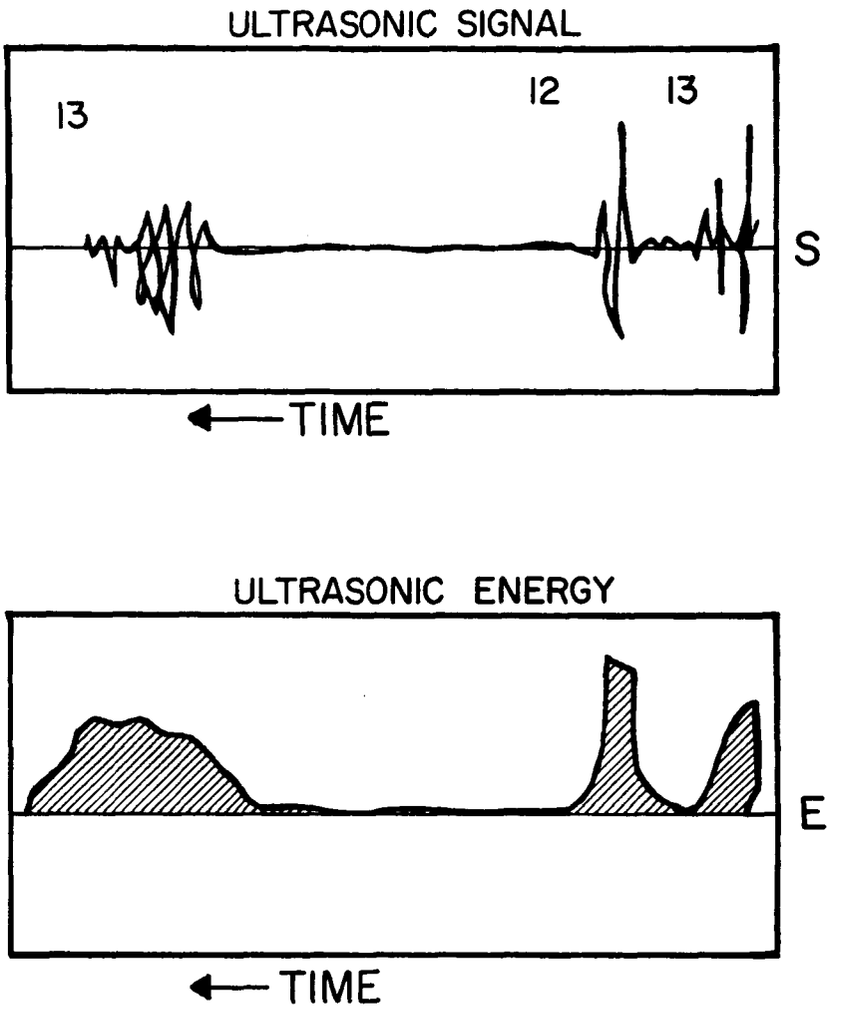

2
11
1
13
12


ULTRASONIC SIGNAL
12
11
13
S
TIME


ULTRASONIC ENERGY
12
11
13
E
TIME

NASA CASE NO. LAR-13689-1-NP
Sheet No. 4 of 6
Inventor: James C. Fletcher et al

FIGURE 5


ULTRASONIC SIGNAL
13
12
13
S
TIME
ULTRASONIC ENERGY
E
TIME

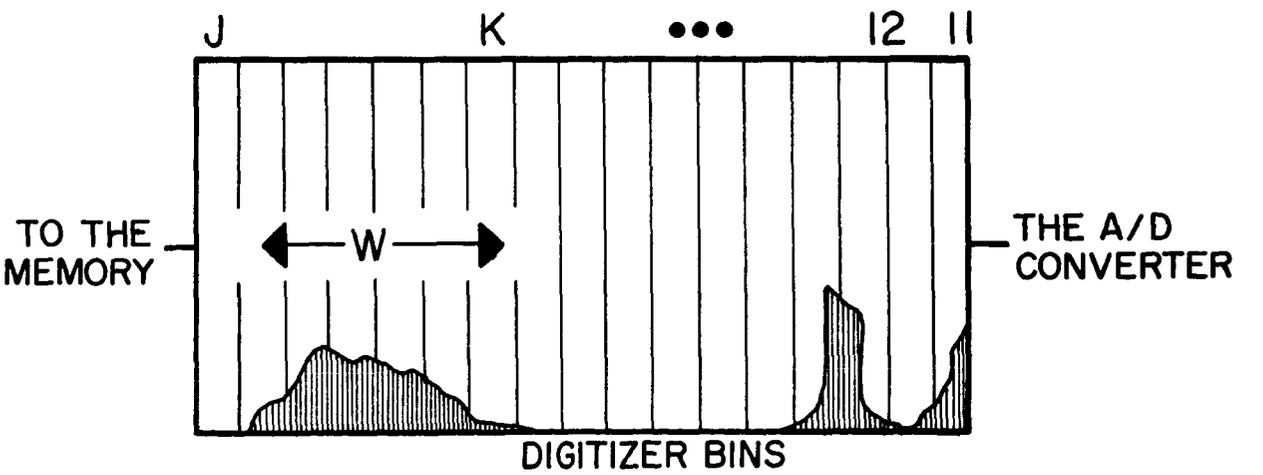
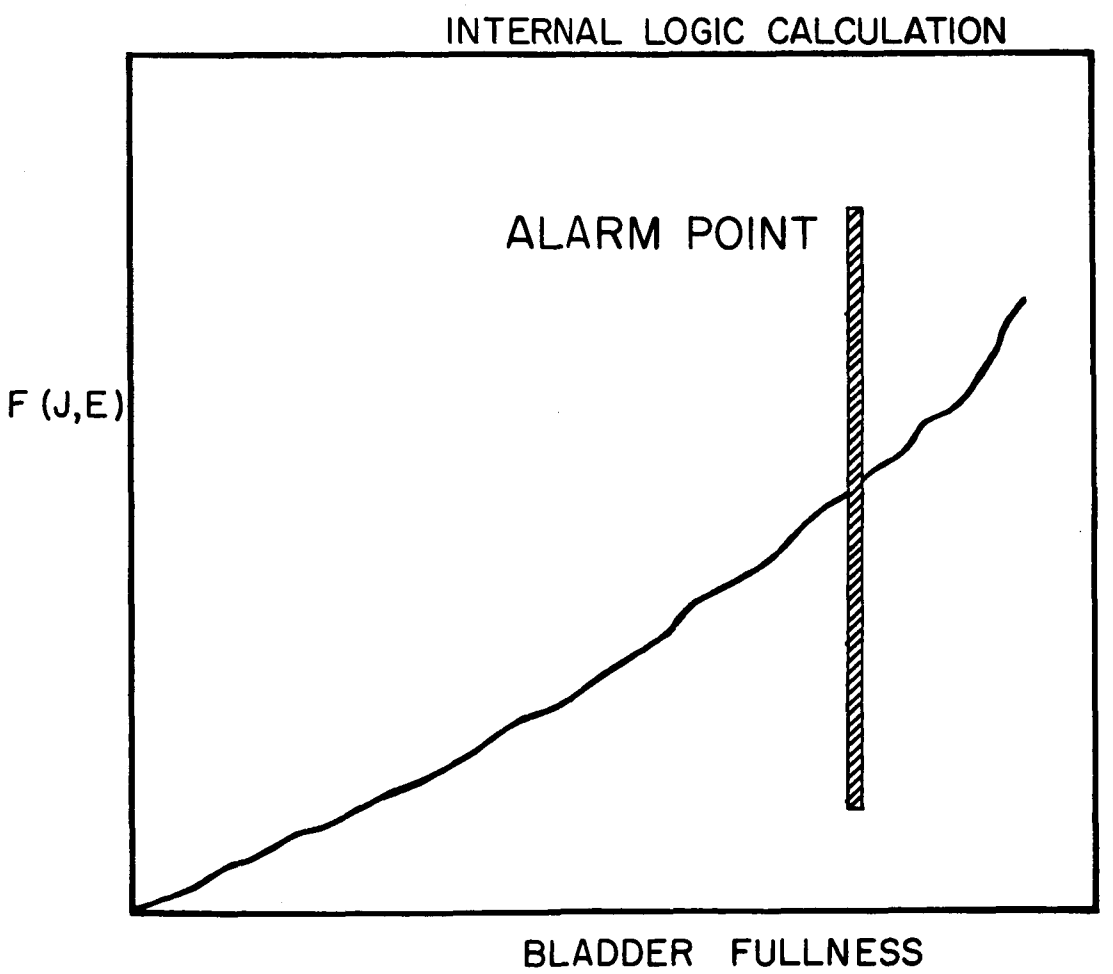

J
K
•••
12
11
TO THE MEMORY
W
THE A/D CONVERTER
DIGITIZER BINS

FIGURE 6


INTERNAL LOGIC CALCULATION
ALARM POINT
F (J,E)
BLADDER FULLNESS

RAPID QUANTIFICATION OF AN INTERNAL PROPERTY

Origin of the Invention

The invention described herein was jointly made: in the performance of work under a U.S. Department of Education/National Institute for Handicapped Research grant to the Association for Retarded Citizens of the United States and is subject to the provisions of the Education Department General Administrative Regulations, revised July 1, 1982; and in the performance of work under a NASA Contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

Background of the Invention

This invention relates generally to the rapid quantification of an internal property of a material as a function of energy transmitted into the material and reflected therefrom. It relates particularly to a method and a device for rapidly quantifying the amount of urine in the bladder of a human subject as a function of ultrasonic energy transmitted into the subject and reflected therefrom.

There has been a longstanding need for a method and a device for the rapid quantification of internal properties of materials. As a particular example, there has been a longstanding need for a method and a device for rapidly quantifying the amount of urine in the bladders of human subjects, especially the mentally retarded, the infirm, and the elderly.

In attempts to normalize the lives of persons with mental retardation, much energy has been devoted to teaching these persons to be able to function independently in society. The problem of incontinence often thwarts the best of these efforts. While sophisticated toilet training programs are quite successful in teaching some persons what to do once the internal sensation of a full bladder is perceived, these programs typically presuppose that a person

is capable of realizing when she/he has to void. The subset of the population of persons with mental retardation for whom continued incontinence is a more common problem are those persons with severe or profound mental retardation, i.e., those with IQs less than 35 and significant deficits in adaptive behavior, who have difficulty in recognizing the subtle and somewhat obscure signals of their bladders.

In addition, there is a substantial need to provide increased independence for persons who have permanently lost the ability to control their bladders for medical reasons such as diabetes, cerebral palsy, quadriplegia, spina bifida, and advanced age.

Incontinence typically results in a negative stigma for the person, reduced positive interaction with other people, unsanitary living conditions, excessive laundry expenses, and increased custodial attention by caregivers. Because of the failure to acquire fundamental toileting skills, such persons are often excluded from a wide variety of vocational, social, and recreational programs, in addition to many preschool programs--all of which are important components of overall experience necessary for their developmental growth and eventual integration into community life.

Previous attempts to employ technology in urinary toilet training fall into two classes. The first class is the wetness detector, which alerts the subject when urine is present on the person. A particular example of this is the employment of a moisture-sensitive apparatus in the clothing or in the bed, which device triggers an alarm when moisture is detected. The second class is the motion-sensitive device, which is located in the toilet. Once voiding has begun, the motion imparted to this device helps the user recognize that urination has been initiated. However, both classes of devices produce their effects after urination has taken place. That is to say, their users are helped to recognize when voiding has been initiated, but they are not helped to recognize the preliminary need to urinate, and thereby make the association between this need and socially-acceptable toileting behavior. In neither case is there a

quantification of the amount of urine in the bladder, which would be of significance in helping one to recognize the preliminary need to urinate.

Urologists have recently employed an ultrasonic device which scans the entire bladder and images it with a sector scan to show the extent of the bladder wall over a sixty degree angle. Other recently-developed devices are based on an ultrasonic "A" scan to reveal the position of the back wall of the bladder, which does move during inflation. However, the scanning systems are very costly, not portable, and require extensive training to use and to interpret the results of such use. Moreover, the "A" scan devices can only reveal the position of the back wall of the bladder. Since the bladder is not a sphere, rectangle, or other simple geometric shape, its volume increases as a complex function, which is dependent on much more information than merely one of its dimensions (viz., that of the back wall). Accordingly, such devices can only provide a relative urine volume while the bladder is partially inflated, and they are useless when the bladder is nearing its maximum size, and the normal urge to eliminate is strongest. In short, these devices do not quantify the amount of urine in the bladder and therefore do not provide information needed by the subject during the critical time when the bladder is at or near its full extension.

It is therefore an object of this invention to provide a method and a device for the rapid quantification of an internal property of a material as a function of energy transmitted into the material and reflected therefrom, thereby fulfilling a longstanding need and obviating the difficulties and inadequacies of the prior art.

It is another object of this invention to provide a method and a device for rapidly quantifying the amount of matter in a container, which is being filled or emptied, as a function of ultrasonic energy transmitted into the material and reflected therefrom.

Yet another object of this invention is to provide a method and a device for rapidly quantifying the amount of matter in an organ of a living being, which is being filled

or emptied, as a function of ultrasonic energy transmitted into the organ and reflected therefrom.

A further object of this invention is to provide a method and a device for rapidly quantifying the amount of urine in the bladder of a human subject, thereby providing information needed by the subject during the critical time when the bladder is at or near its full extension and affording help to the subject in recognizing the preliminary need to urinate.

Other objects and advantages of this invention will become apparent in the specification and drawings which follow.

Summary of the Invention

The present invention comprehends the provision of a transducer, which is positioned in proximity to the material under test, for the purpose of transmitting energy into the material followed by receiving energy reflected from the material. An ultrasonic transducer is especially useful, particularly when the material under test is a container which is being filled or emptied, such as an organ of a living being, especially the bladder of a human subject. A pulser/receiver communicates with a source of power and the transducer and excites the transducer to transmit energy. It also amplifies and processes the reflected energy received by the transducer. A converter communicates with the pulser/receiver to digitize the analog signal from the pulser/receiver. A memory communicates with the converter for storage of the digital signal from the converter. A logic system communicates with the pulser/receiver to command excitation of the transducer. The logic system communicates additionally with the converter to command digitization of the analog signal from the pulser/receiver. The logic system also communicates with the memory and processes the stored digital signal from the converter along with digital input based on the particular characteristics of the specific material under test, thereby rapidly quantifying the internal property of the material as a

function of the propagated energy. When the material under test is a container being filled or emptied, such as an organ of a living being, especially the bladder of a human subject, it is advantageous to provide an alarm to alert the subject or another person at a remote location when the amount of urine in the bladder has reached a given level.

Brief Description of the Drawings

For a more complete understanding of the present invention, including its objects and benefits, reference should be made to the detailed description, which is set forth below. This detailed description should be read together with the accompanying drawings, wherein:

FIG. 1 is a schematic showing the components of a preferred embodiment of the present invention;

FIGS. 2-4 are schematics illustrating the interaction of acoustic waves with the bladder of a human subject in accord with the preferred embodiment; and

FIG. 5 is a schematic and FIG. 6 is a graph illustrating in detail the function and operation of the components of the preferred embodiment of FIG. 1.

Detailed Description of the Invention

Turning now to a preferred embodiment of the present invention which has been selected as illustrative for depiction in the drawings, FIG. 1 shows an ultrasonic transducer (1), which is excited by pulser/receiver (3) under command of logic (4) to launch an acoustic wave into patient (2). The wave interacts with the bladder wall (See FIGS. 2-4 and discussion infra.) and is reflected back to the ultrasonic transducer (1). It is then amplified and processed by pulser/receiver (3). The resulting signal is digitized by the analog-to-digital converter (5) under command of logic (4), and is stored in memory (6). The software in the logic system (4) determines the bladder fullness based on scientific measurements and past history with the specific patient, and sends out a signal to turn on

any or all of the audible (7), the visible (8), the tactile (9), and the remote wireless alarm (10).

To better understand the function and operation of the invention, it is necessary to examine the acoustic wave interaction with the bladder as is shown in FIGS. 2-4. In FIG. 2, the bladder is essentially empty. In FIG. 3, the bladder is being filled, and in FIG. 4, the bladder is at maximum fullness. In each of FIGS. 2-4 are simplified, illustrative diagrams of the physical bladder and the ultrasonic transducer (top), a conventional ultrasonic signal S showing the radio frequency (RF) wave forms (middle), and the energy wave forms E (bottom). Each of FIGS. 2-4 shows the tissue/transducer interface 11, the bladder front wall 12, and the bladder back wall 13.

In FIG. 2, with the bladder essentially empty, transducer (1) is placed on the patient with a conventional couplant for ultrasound. The sound wave excited by the pulser/receiver (3) of FIG. 1 causes the ultrasonic signal shown in FIG. 2, diagram S, time position 11. The wave also reflects off the bladder front wall 12 and the bladder back wall 13, with the resulting ultrasonic signals 12 and 13, respectively, in diagram S. The bottom diagram E in FIG. 2 is the ultrasonic energy with its corresponding signals 11, 12, and 13. These signals are obtained by adding the absolute amplitude of the RF wave forms for each pulse and averaging the resulting summation over N cycles of the measurement, as determined by the programmed logic. It should be noted that the energy is positive definite.

In FIG. 3, with the bladder partially full, the bladder has inflated as shown in the upper part of the figure, and the RF waveforms have changed as the bladder shape has changed. In particular, the back wall reflection has moved back in time, and additional reverberation has built up in the back wall signal as shown in S, wave (3) as well as in E, wave (3).

In FIG. 4, with the bladder full, the change in shape has continued, although the back wall has not moved in a simple fashion during filling. The energy seen in the back

wall reflection, however, continued to increase as the bladder filled. In fact, for a bladder filling past about 60% fullness, the back wall hardly moves at all, while the energy reverberation at the back wall continues to increase. Thus, it can be seen that a monitor of the back wall position only would not be accurate during critical near-full periods. In sharp contrast thereto, this invention, which measures the energy in the back wall reflection as well as the back wall position, is accurate as a monitor for the entire range of bladder fullness.

FIGS. 5 and 6 show the internal components of this invention and their function in more detail. The converter (5) and the memory (6) actually act as a signal averager, taking the digitizer output and multiplying it by some function of bin number and energy (F(J,E)), while checking that the signal falls in the correct time range or bin number (J). The entire operation is controlled by the software to configure the function and the mathematical operations for the specific subject.

As the simplist case, the function used is the sum of energy amplitudes in bins (J-K+W) that correspond to the back wall and beyond of the bladder, where W is the width of the reverberation signal at the back wall. A check on the data quality is that bins less than (J-K) show no significant amplitude. Such a lack of signal corresponds to the fact that when the bladder contains water, the path length between the front and back walls should show no scattering, i.e., a simple water path exists.

The internal logic calculation of FIG. 6 shows the result of a typical bladder during filling. The function has been adapted to the specific subject so that the F(J,E) and the alarm point correspond to the best time for that subject to be notified to urinate.

A complete electronics package is worn by the subject with the transducer positioned by means of a flexible mounting belt. The electronics package advantageously contains means to alert the subject with any of a variety of stimuli including a tactile alarm (e.g., a vibrator), a visual alarm (e.g., an LED mounted on eyeglasses), an

audible alarm (e.g., a buzzer), and a remote alarm (an RF link to a receiver monitor). In addition, the electronics package advantageously contains a working mode which lets the package work in a "sleep" configuration when the bladder should be empty (after successful elimination). In that mode, the frequency of pulses and measurements is reduced to lengthen the life of the power supply (which is advantageously a battery) in the package. Moreover, parameters governing the user's interaction with the device, by the user or his/her caregiver into the logic system externally by adjusting controls on the face of the logic unit. This affords a customization for each individual and a quick and simple modification of existing parameters at any time. The user is accordingly allowed to select the level of bladder fullness at which she/he would like the alarm to sound.

As is understood by those of skill in the art, the ultrasonic transducer, pulser/receiver, analog-to-digital converter, memory, audible alarm, visual alarm, tactile alarm, and remote alarm employed herein are per se well-known, and therefore are not disclosed in detail herein.

The preferred embodiment disclosed hereinabove relates to the propagation of ultrasonic energy and averaging the energy signals over a number of measurement cycles to rapidly quantify the amount of urine in the bladder of a human subject. Moreover, the programming of specific functions of the particular subject into the logic system permits a fine tuning which affords accurate operation with a wide variety of subjects and conditions. However, it is understood by those of skill in the art that other forms of energy may be employed in the practice of the present invention, and that the invention as broadly comprehended may be used to rapidly quantify internal properties of a wide variety of materials wherein changes in the propagated signal are related to a function of the desired monitoring variable. Particularly comprehended is the rapid quantification of the amount of matter in a container, especially one being filled or emptied, and the amount of

matter in other organs of a living being which are being filled or emptied.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

RAPID QUANTIFICATION OF AN INTERNAL PROPERTY

Abstract of the Disclosure

A device and method for the rapid quantification of an internal property of a material are typified by embodiments for rapidly quantifying the amount of urine in the bladder of a human subject. Ultrasonic transducer 1 which is positioned on the subject 2 in proximity to the bladder 12-13, is excited by pulser/receiver 3 under command of logic 4 to launch an acoustic wave into patient 2. This wave interacts with the bladder walls 12,13 and is reflected back to the ultrasonic transducer 1, whence it is amplified and processed by pulser/receiver 3. The resulting signal is digitized by analog-to-digital converter 5 under command of logic 4, and is stored in memory 6. The software in logic system 4 determines the amount of urine in the bladder as a function of the propagated ultrasonic energy and based on programmed scientific measurements and past history with the specific subject, and sends out a signal to turn on any or all of the audible alarm 7, the visible alarm 8, the tactile alarm 9, and the remote wireless alarm 10.